Appendix C

Table C-1: Raw data of Volume fraction of reinforcement.

Mg/4.8SiC$_P$			
Specimen	Weight fraction	Average Weight fraction	Theoretical volume fraction
1	4.76	4.82±0.07	2.7
2	4.81		
3	4.89		

Mg/10.2SiC$_P$			
Specimen	Weight fraction	Average Weight fraction	Theoretical volume fraction
1	10.28	10.18±0.19	5.8
2	9.97		
3	10.30		

Mg/15.4SiC$_P$			
Specimen	Weight fraction	Average Weight fraction	Theoretical volume fraction
1	15.15	15.42±0.39	9.0
2	15.25		
3	15.87		

Mg/5.02SiC$_P$/2.7Ti$_P$					
Specimen	Weight fraction	Average Weight fraction		Theoretical volume fraction	
	SiC$_P$	SiC$_P$	Ti$_P$	SiC$_P$	Ti$_P$
1	4.96	5.02±0.09	2.7	2.8	1.1
2	4.98				
3	5.12				

Mg/9.9SiC$_P$/2.7Ti$_P$					
Specimen	Weight fraction	Average Weight fraction		Theoretical volume fraction	
	SiC$_P$	SiC$_P$	Ti$_P$	SiC$_P$	Ti$_P$
1	9.56	9.92±0.35	2.7	5.7	1.1
2	9.94				
3	10.26				

Mg/14.93SiC$_P$/2.7Ti$_P$					
Specimen	Weight fraction	Average Weight fraction		Theoretical volume fraction	
	SiC$_P$	SiC$_P$	Ti$_P$	SiC$_P$	Ti$_P$
1	15.13	14.93±0.18	2.7	8.8	1.1
2	14.79				
3	14.86				

Appendix D

Table D-1: CTE values of monolithic magnesium.

Specimen	Pure Magnesium
1	27.768
2	28.33
3	27.971
Average	28.02±0.28

Table D-2: CTE values of Mg/SiC_P composites.

Specimen	Mg/4.8SiC_P	Mg/10.2SiC_P	Mg/15.4SiC_P
1	23.534	21.541	21.324
2	23.173	21.412	21.381
3	24.369	20.615	20.418
Average	23.77±0.84	21.19±0.50	21.04±0.54

Table D-3: CTE values of Mg/SiC_P after Heat treatment.

Specimen	Mg/4.8SiC_P	Mg/10.2SiC_P	Mg/15.4SiC_P
1	23.525	23.211	22.127
2	23.943	23.144	21.984
3	24.083	23.011	22.512
Average	23.58±0.29	23.12±0.10	22.21±0.27

Table D-4: CTE values of Mg/SiC_P/Ti_P composites.

Specimen	Mg/5.02SiC_P/2Ti_P	Mg/9.92SiC_P/2Ti_P	Mg/14.93SiC_P/2Ti_P
1	22.984	21.657	20.529
2	24.959	23.077	19.862
3	22.316	23.736	19.351
Average	23.41±1.37	22.82±1.06	19.91±0.59

Appendix E

Table E-1: Macro hardness values for Mg and Mg/SiC_P materials.

HR15T	Monolithic Mg	Mg/4.8SiC_P	Mg/10.2SiC_P	Mg/15.4SiC_P
1	47.6	59.0	59.0	62.6
2	46.8	59.2	59.5	62.4
3	47.2	57.1	57.3	63.5
4	48.2	57.2	58.6	61.8
5	46.3	56.9	58.4	63.5
Average	47.22±0.73	57.78±0.98	58.56±0.82	62.76±0.74

Table E-2: Macro hardness values of Heat treated Mg/SiC_P materials.

HR15T	Mg/4.8SiC_P	Mg/10.2SiC_P	Mg/15.4SiC_P
1	55.3	55.5	59.9
2	56.1	60.2	60.1
3	57.9	59.8	61.1
4	54.1	59.7	60.3
5	57.2	55.1	60.8
Average	56.12±1.51	58.06±2.53	60.44±0.50

Table E-3: Macro hardness values of Mg/5.02SiC_P/2.7Ti_P materials.

HR15T	Mg/5.02SiC_P/2.7Ti_P	Mg/9.92SiC_P/2.7Ti_P	Mg/14.93SiC_P/2.7Ti_P
1	49.8	52.9	64.4
2	47.7	50.4	65.3
3	48.7	51.4	65.2
4	45.3	50.4	63.7
5	45.0	51.0	65.4
6	47.1	52.4	63.2
7	49.8	50.8	67.2
8	49.2	54.2	64.8
9	47.5	52.6	65.6
10	49.1	51.2	65.9
Average	47.92±1.73	51.73±1.25	65.07±1.13

Table E-4: Micro hardness values of Monolithic Magnesium.

H_V	Monolithic Magnesium
1	41.1
2	42.3
3	40.5
4	40.8
5	41.5
Average	41.24±0.70

Table E-5: Micro hardness values of Mg/SiC_P materials.

H_V	Mg/4.8SiC_P	Mg/10.2SiC_P	Mg/15.4SiC_P
1	52.2	56.6	57.8
2	52.4	57.1	56.0
3	53.0	56.1	52.0
4	53.9	54.4	57.4
5	54.9	53.9	56.4
6	52.9	53.7	55.5
Average	53.22±1.01	55.30±1.48	55.85±2.07

Table E-6: Micro hardness values of Heat treated Mg/SiC_P materials.

H_V	Mg/4.8SiC_P	Mg/10.2SiC_P	Mg/15.4SiC_P
1	49.5	49.1	58.2
2	49.9	51.9	53.8
3	49.3	49.0	54.3
4	50.6	52.1	52.9
5	51.3	53.4	52.3
6	49.6	50.8	52.5
7	47.7	52.3	57.8
8	52.5	52.0	52.9
9	52.2	51.9	49.9
10	52.9	53.1	54.6
Average	50.6±1.7	51.56±1.5	53.9±2.5

Table E-7: Micro hardness values of $Mg/SiC_P/Ti_P$ materials.

H_V	$Mg/5.02SiC_P/2.7Ti_P$		$Mg/9.92SiC_P/2.7Ti_P$		$Mg/14.93SiC_P/2.7Ti_P$	
	Matrix	Interface(Ti_P)	Matrix	Interface(Ti_P)	Matrix	Interface(Ti_P)
1	49.0	51.6	49.6	52.5	67.2	69.1
2	49.8	51.5	49.1	53.8	65.8	69.3
3	46.5	55.7	50.2	56.5	66.1	75.9
4	48.6	54.8	47.0	55.1	66.0	72.2
5	48.4	54.3	47.8	54.9	66.5	70.0
6	-	-			66.2	69.3
Average	48.46±1.22	53.58±1.92	48.74±1.31	54.56±1.50	66.3±0.50	70.97±2.68

Appendix F

Room temperature tensile test raw data

Table F-1: Tensile test results of monolithic magnesium.

Monolithic Magnesium				
Specimen	Dynamic Elastic Modulus(GPa)	0.2% Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Ductility (%EL)
1	--	163.64	202.54	7.8
2	--	150.59	204.87	9.1
3	--	145.86	212.63	9.8
4	--	153.48	207.95	9.9
Average	39.82	153.39±7.52	206.99±4.36	9.15±0.97

Table F-2: Tensile test results for the Mg/SiC composite samples.

Mg/4.8SiC$_p$				
Specimen	Elastic Modulus(GPa)	0.2% Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Ductility (%EL)
1	--	182.04	221.38	2.9
2	--	179.92	219.68	2.1
3	--	183.21	217.07	1.2
Average	45.60	181.72±1.67	219.38±2.17	2.07±0.85
Mg/10.2SiC$_p$				
Specimen	Elastic Modulus(GPa)	0.2% Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Ductility (%EL)
1	--	167.97	204.51	1.71
2	--	173.30	225.01	1.42
3	--	170.19	232.22	1.30
Average	47.22	170.49±2.68	220.58±14.38	1.48±0.21
Mg/15.4SiC$_p$				
Specimen	Elastic Modulus(GPa)	0.2% Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Ductility (%EL)
1	--	154.51	215.97	1.40
2	--	154.06	200.05	1.32
3	--	155.64	199.00	1.28
4	--	156.03	213.45	1.38
Average	48.24	155.06±0.93	207.12±8.84	1.35±0.06

Table F-3: Tensile test results for the Heat treated Mg/SiC composite samples.

Mg/4.8%SiC (HT)			
Specimen	0.2% Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Ductility (%EL)
1	210.24	247.95	2.87
2	196.6	232.26	2.56
3	192.64	219.65	3.2
Average	199.83±9.23	233.29±14.18	2.88±0.32
Mg/10.2%SiC (HT)			
Specimen	0.2% Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Ductility (%EL)
1	164.38	212.32	2.4
2	160.23	200.12	3.7
3	167.82	181.32	2.6
Average	164.14±3.80	197.92±15.62	2.9±0.70
Mg/15.4%SiC (HT)			
Specimen	0.2% Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Ductility (%EL)
1	164.68	209.12	3.9
2	173.48	211.5	2.6
3	164.75	216.66	4.2
Average	167.64±5.06	212.43±3.85	3.57±0.85

Table F-4: Tensile test results for the Mg/SiC/Ti composite samples.

Mg/5.02SiC$_P$/2.7Ti$_P$				
Specimen	Elastic Modulus(GPa)	0.2% Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Ductility (%EL)
1	--	177.54	221.9	3.1
2	--	162.79	187.46	1.9
3	--	165.63	203.66	3.0
Average	46.76	168.65±7.83	204.34±17.23	2.67±0.67
Mg/9.92SiC$_P$/2.7Ti$_P$				
Specimen	Elastic Modulus(GPa)	0.2% Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Ductility (%EL)
1	--	166.75	208.67	3.7
2	--	151.05	179.97	1.8
3	--	165.42	207.55	3.4
Average	47.96	161.07±8.71	198.73±16.26	2.87±0.95
Mg/14.93SiC$_P$/2.7Ti$_P$				
Specimen	Elastic Modulus(GPa)	0.2% Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Ductility (%EL)
1	--	218.6	239.82	1.02
2	--	214.62	232.26	1.1
3	--	217.81	227.19	1.0
Average	51.81	217.01±2.11	233.09±6.36	1.04±0.05

Appendix G

Calculation of Scratch hardness using the measured value of scratch width.

$$HS_P = \frac{24.98 \times m}{x^2}$$

where m – Normal Load in gr, w – scratch width in micron.

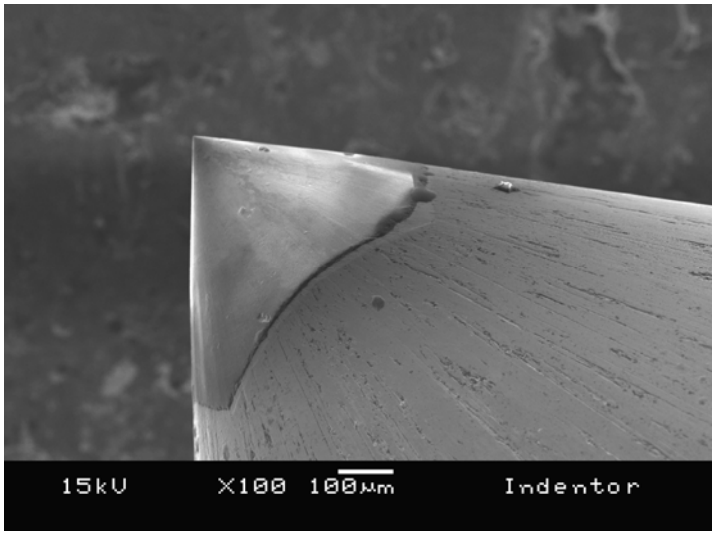


Fig G-1: SEM micrograph showing the Diamond indenter used for scratch testing.

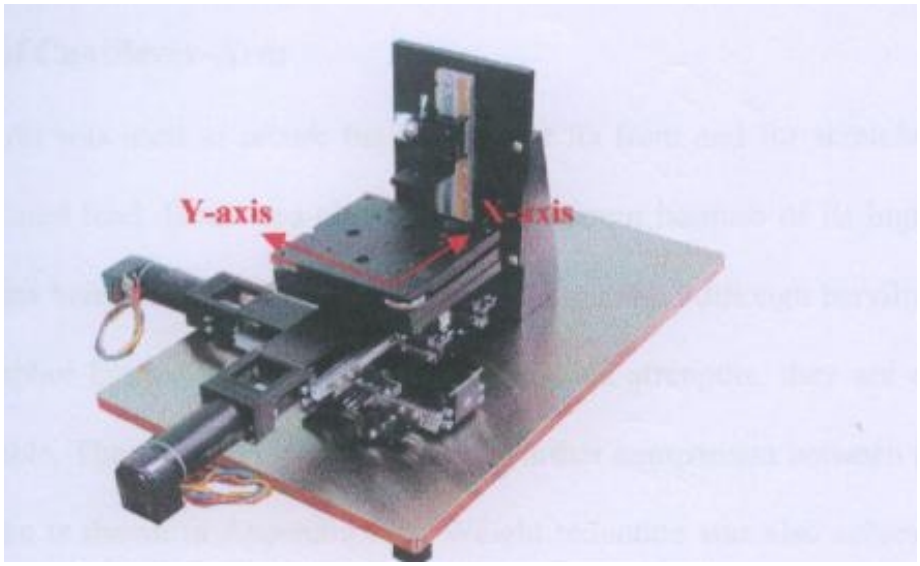


Fig G-2: Set-Up for scratch testing.

Table G-1: Scratch Characterization Data for Pure Mg.

Specimen	Scratch Width(μm)		Scratch Hardness (MPa)		Average COF	
	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)
1	45.64	48.86	718.58	711.70	1.73	1.74
2	46.72	46.63	685.74	691.35		
3	44.88	45.01	743.12	738.83		
4	45.04	45.12	737.85	735.23		
Average	45.57±0.83	45.63±0.71	721.32±25.96	719.28±22.17		

Table G-2: Scratch Characterization Data for Mg/4.8SiC composite material.

Specimen	Scratch Width(μm)		Scratch Hardness (MPa)		Average COF	
	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)
1	41.45	41.57	871.19	906.71	1.79	1.80
2	41.09	41.88	886.53	853.40		
3	40.70	40.85	903.60	896.97		
4	42.88	42.21	814.06	849.34		
Average	41.53±0.95	41.63±0.58	868.84±38.85	864.16±24.33		

Table G-3: Scratch Characterization Data for Mg/10.2SiC composite material.

Specimen	Scratch Width(μm)		Scratch Hardness (MPa)		Average COF	
	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)
1	39.94	40.04	938.31	933.63	1.80	1.84
2	41.62	40.21	864.09	925.76		
3	39.24	39.96	972.09	937.37		
4	39.62	40.31	953.53	921.17		
Average	40.11±1.05	40.13±0.16	932.01±47.34	929.48±7.36		

Table G-4: Scratch Characterization Data for Mg/15.4SiC composite material.

Specimen	Scratch Width(μm)		Scratch Hardness (MPa)		Average COF	
	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)
1	38.55	38.65	1007.20	1001.99	1.83	1.86
2	40.12	40.15	929.91	928.52		
3	39.24	39.64	972.09	952.57		
4	39.01	39.01	983.59	983.59		
Average	39.23±0.66	39.36±0.67	973.20±32.35	966.67±32.60		

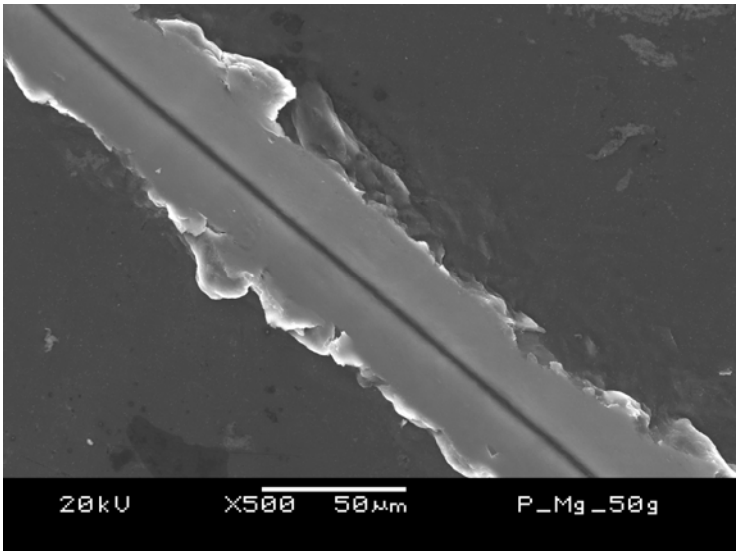
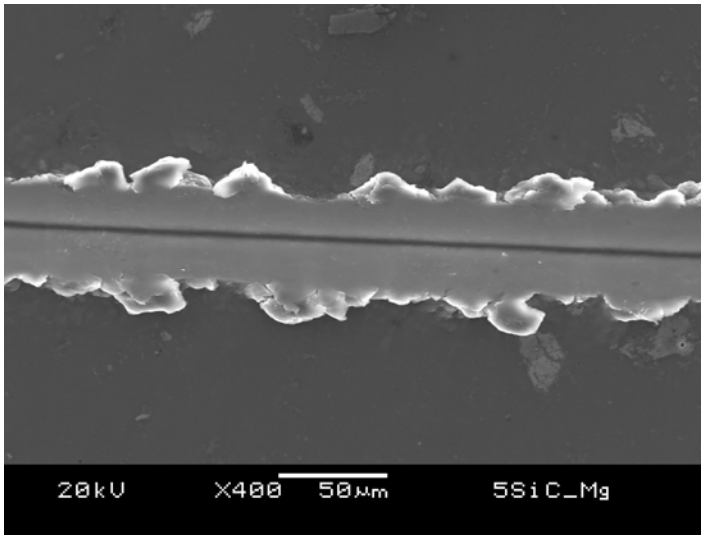
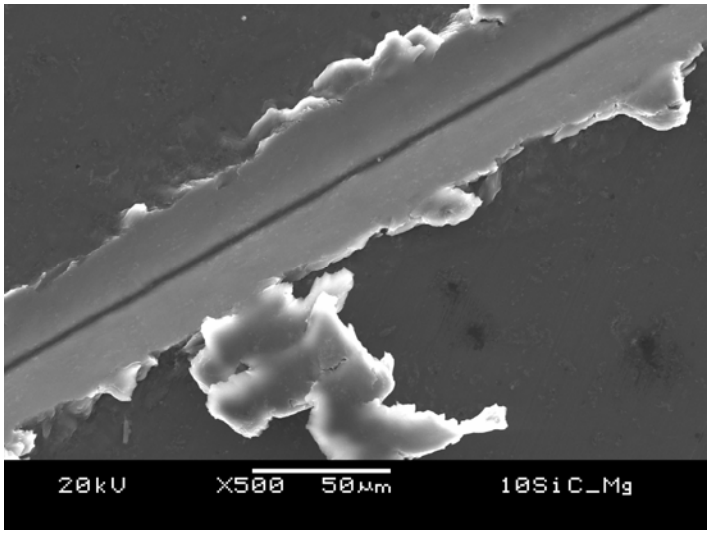


Fig G-3: Representative SEM micrograph showing scratch on Pure Magnesium when scratched by 90^0 included angle diamond stylus at a normal load of 0.54N and 0.2mm/s scratch velocity.



(a)



(b)

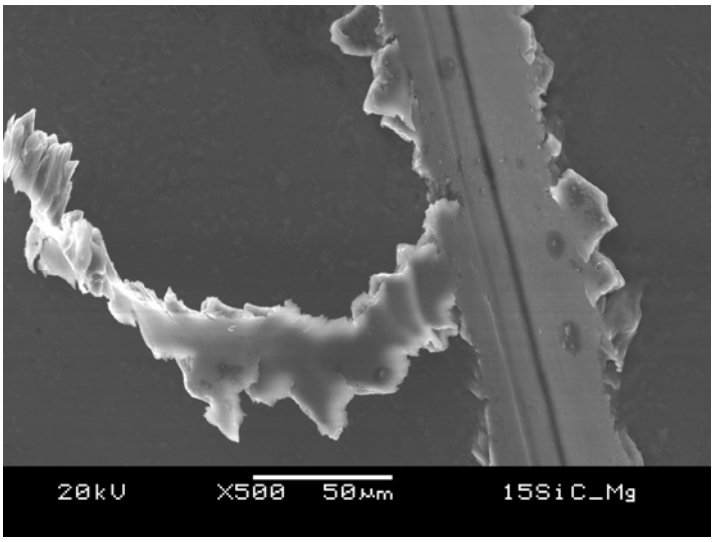


Fig. G-4: Scratch Micrographs of a) Mg/4.8SiC, b) Mg/10.2SiC, and c) Mg/15.4SiC at a normal load of 0.54N and 0.2mm/s scratch velocity.

Table G-5: Scratch Characterization Data for Mg/5.02SiC/2.7Ti composite material.

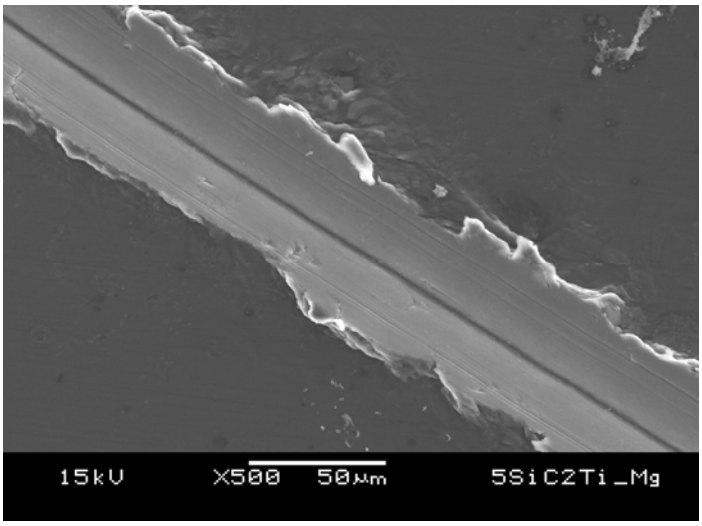
Specimen	Scratch Width(μm)		Scratch Hardness (MPa)		Average COF	
	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)
1	41.57	41.89	866.17	852.99	1.77	1.79
2	41.89	42.36	852.99	834.17		
3	42.1	42.56	844.50	826.34		
4	42.65	42.08	822.86	845.30		
Average	42.05±0.45	42.22±0.30	846.63±18.18	839.70±11.79		

Table G-6: Scratch Characterization Data for Mg/9.92SiC/2.7Ti composite material.

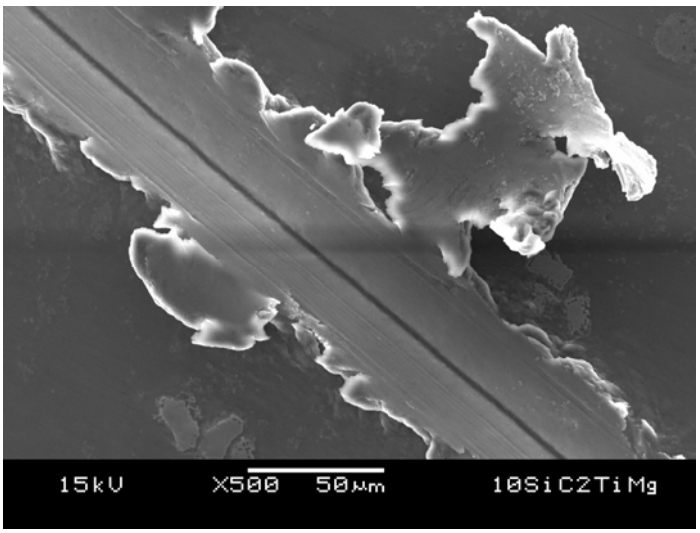
Specimen	Scratch Width(μm)		Scratch Hardness (MPa)		Average COF	
	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)
1	38.16	40.25	925.29	923.92	1.89	1.92
2	40.22	40.41	870.35	916.61		
3	41.47	39.96	978.56	937.37		
4	39.11	39.11	1027.89	978.56		
Average	39.74±1.43	39.93±0.58	950.53±67.91	939.12±27.67		

Table G-7: Scratch Characterization Data for Mg/14.93SiC/2.7Ti composite material.

Specimen	Scratch Width(μm)		Scratch Hardness (MPa)		Average COF	
	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)	Load (55gm)	Load (75gm)
1	40.66	40.21	905.38	925.76	1.88	1.91
2	38.56	39.31	1006.68	968.63		
3	39.11	39.25	978.56	971.59		
4	38.98	39.54	985.10	957.39		
Average	39.33±0.92	39.58±0.44	968.93±44.04	955.84±20.97		



(a)



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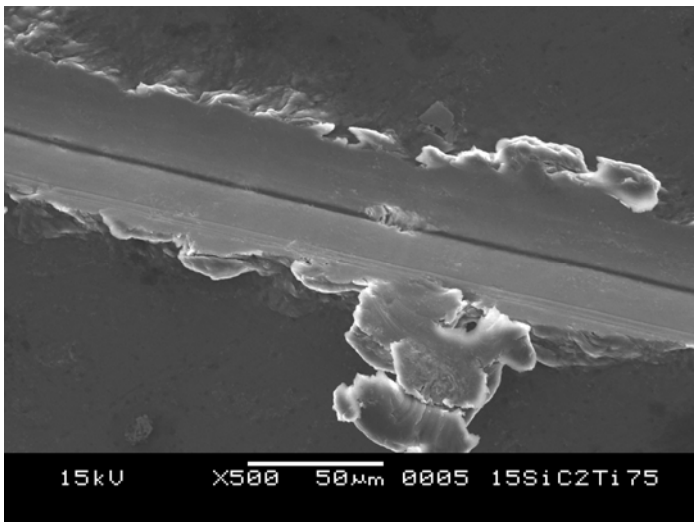
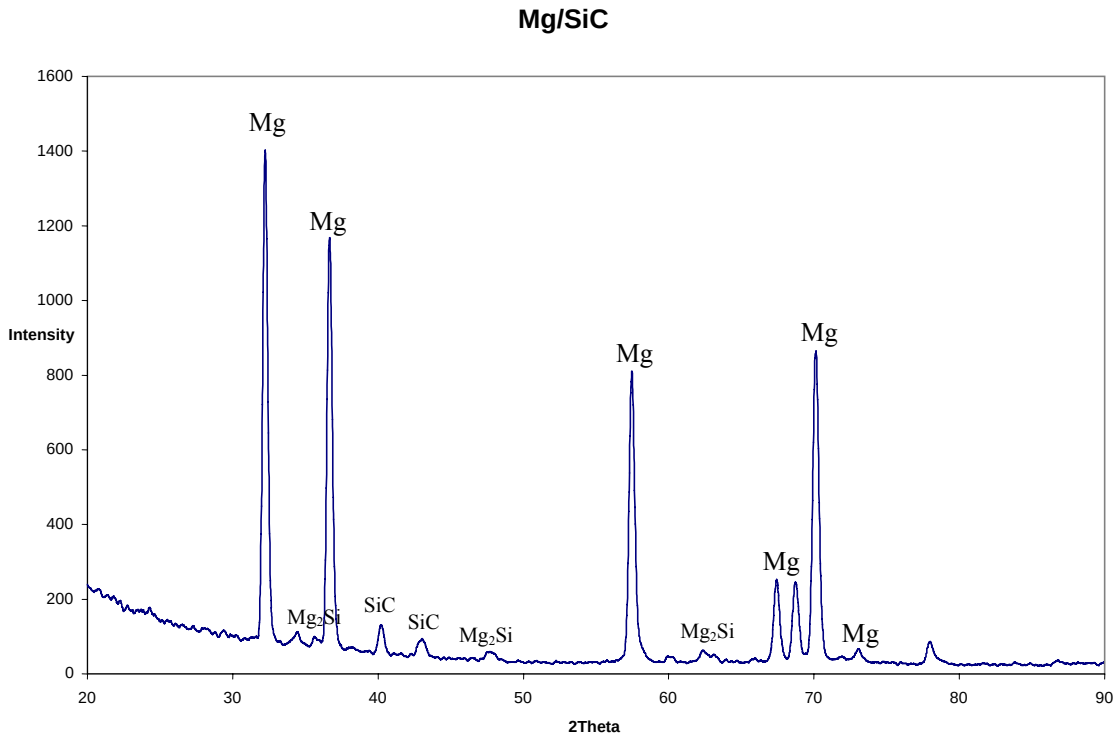


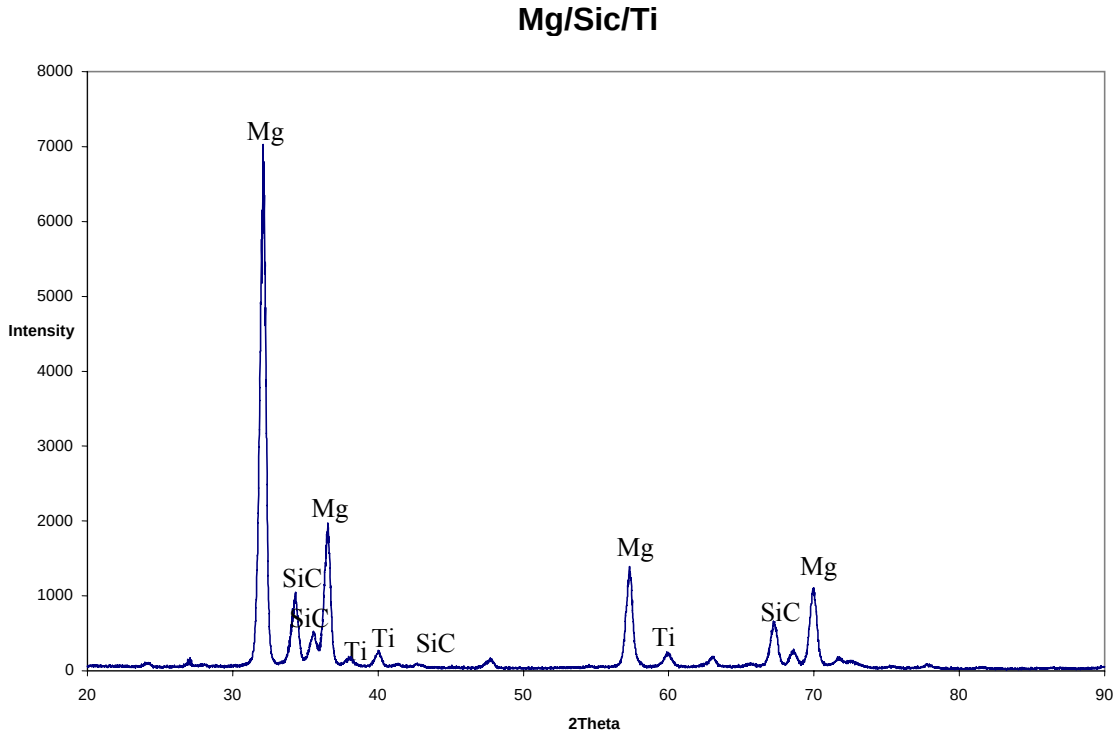
Fig. G-5: Micrographs showing the scratch profiles of Mg/SiC/Ti samples done at 0.74N load and 0.2mm/s velocity (a) Mg/5.02SiC/2.7Ti (b) Mg/9.92SiC/2.7Ti (c) Mg/14.93SiC/2.7Ti.

Appendix H

XRD spectrum of Composite samples



Representative XRD spectrum of Mg/SiC composite specimens



Representative XRD spectrum for Mg/SiC/Ti composite samples.